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Update of the review: Cultivation of energy crops in Poland against socio-demographic factors

Justyna Chodkowska-Miszczuk, Daniela Szymańska *

Nicolaus Copernicus University, Gagarina 9, 87-100 Toruń, Poland

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ABSTRACT

The article presents some of the socio-demographic factors conditioning the production of biomass in Poland (update of the review). It considers urban-rural and rural gminas that grew energy crops for biomass production in the years 2007–2009 (836 gminas in 2007, 756 in 2008 and 618 in 2009). The article tries to answer the question whether there is a relation between the age of the inhabitants, their opinion on Poland's accession to the European Union and the education level of the local authorities and the area of energy crops in a given gmina. The research uses the correlation coefficient and the analysis of segmented regression.

Contents

1. Introduction

Since earliest times biomass was used by humans as a basic source of energy. In many parts of the world, including Poland, energy crops, alongside wind energy, are presently seen as the prospective source of renewable energy. Among a number of types of biomass, such as wood, farm products and animal substances, energy crops are most important. This is mainly conditioned by low investment costs connected with both processing and burning them. Moreover, energy crops are easily stored and converted into diverse energy sources [1,2]. It is also crucial that growing energy crops favours further multifunctional development of rural areas and increases competitiveness of the farming sector [3–5].

In Poland interest in plant biomass intensified due to the state policy regarding the development of alternative sources of energy. In the years 2007–2009 farmers could increase their income through subsidies on energy crops. Initially these funds came from the state budget (2005–2006). Later on, however, they also came from the EU funds.

Cultivation of energy crops in Poland is unevenly spread. The largest aggregations of areas taken by energy crops are found in the western part of Poland. Initially (2007) the leading voivodeship (i.e. administrative region of the 1st order) in terms of the area taken by the energy crops was Zachodniopomorskie voivodeship. Since 2008 it was Opolskie voivodeship, which in 2009 claimed nearly 1/3 of the total area of energy crops cultivated in Poland [6].

2. Materials and research methods

The research included rural and urban-rural gminas (i.e. administrative region of the 3rd order), in which energy crops were

* Corresponding author. Tel.: +48 56 6112606; fax: +48 56 6112605.
E-mail address: dani@umk.pl (D. Szymańska).

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cultivated in the years 2007–2009. In 2007 there were 836 such gminas, in 2008 – 756, and in 2009 – 618. Selected socio-demographic factors were studied in the context of energy crop production. They include percentage of working age population, the share of gmina council members with secondary and post-secondary education, as well as the percentage of population supporting Poland's accession to the European Union in 2003.

Correlation coefficients were used in the study; all values of the correlation coefficient was calculated at the 0.05 significance level. However, due to low values of these coefficients, the analysis of segmented regression (segmented linear) was used. This regression shows the character of the interdependence which may not be linear. The analysis was based on the following equations:

$$Y = (b_{01} + b_{11} \times x_1 + \cdots + b_{m1} \times x_m) \times (y \leq b_0) + (b_{02} + b_{12} \times x_1 + \cdots + b_{m2} \times x_m) \times (y > b_0)$$

Y is the estimated value; y the real value; b_0 the breakpoint value; b_{01}, b_{02} the regression constant; $b_{11} \ldots b_{ij}$ the section coefficients of regression; and $x_1 \ldots x_m$ is the independent variables.

The model of segmented regression describes two separate equations of line regression: one for the y values which are lower than or equal the breakpoint (b_0), while the other one for the larger values. Usefulness of the equations was tested with the use of the value of the determination coefficient (R^2). All the calculations were made with the use of the program *Statistica 9.0*.

3. Socio-demographic conditions for production of energy crops

Production of energy crops is one of the initiatives which activate economy in rural areas in Poland. Thus, besides economic and political factors, the analysis needs to consider the role of a human factor. Creation, realization and consumption depend on people. As R. Florida indicates, human capital is crucial for both regional and local development. Investors are attracted by the quality of human capital expressed through the level of education and motivation of potential workers, which to a certain extend depend on age [7].

3.1. Age structure of energy crops producers

A characteristic feature of the age structure of population in the studied gminas in the years 2007–2009 is that the percentage of

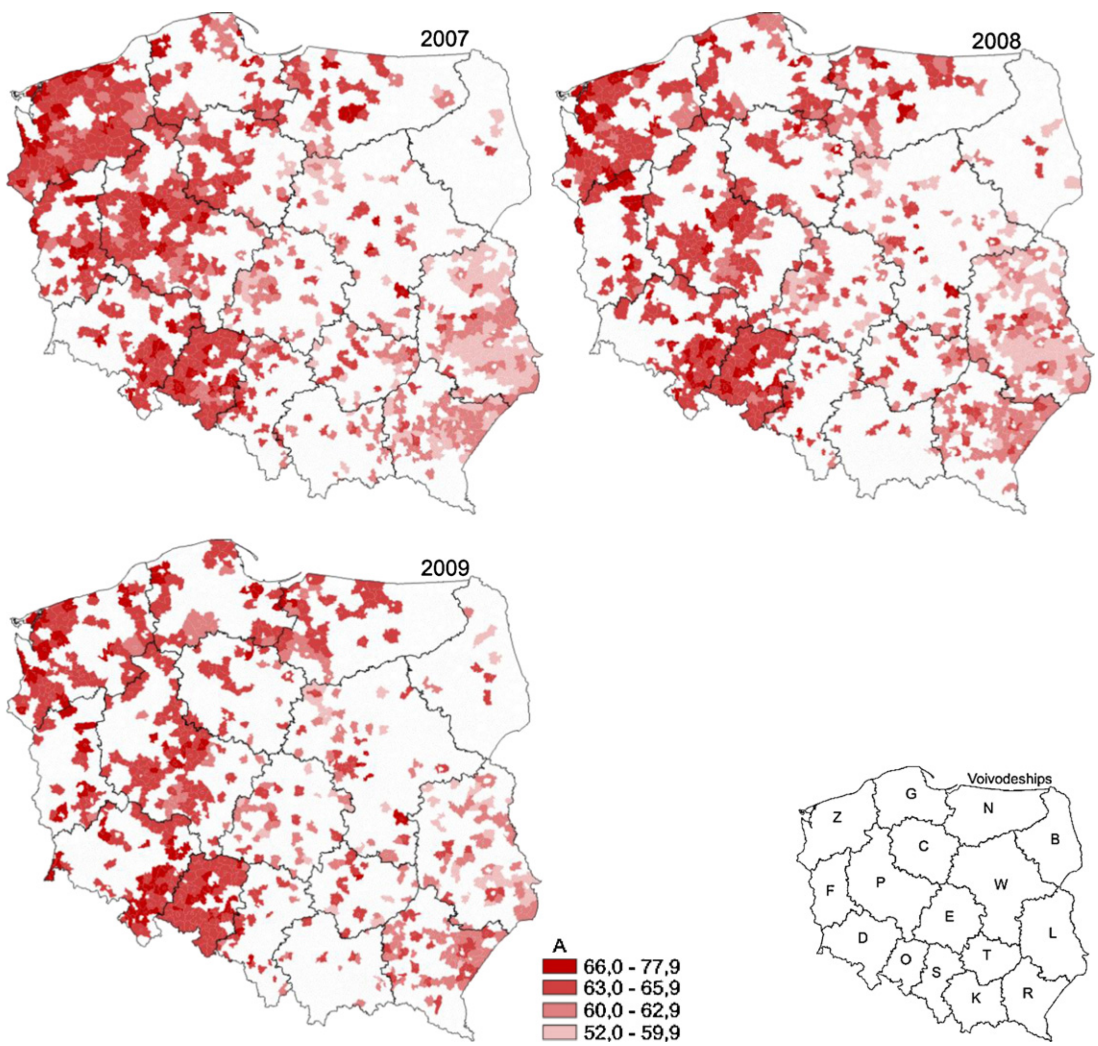


Fig. 1. Shares of working age population in the gminas where energy crops were grown in the years 2007–2009. Explanation: A, shares of working age population in total population (%); Voivodeships: B, Podlaskie; C, Kuiawsko-Pomorskie; D, Dolnośląskie; E, Łódzkie; F, Lubuskie; G, Pomorskie; K, Małopolskie; L, Lubelskie; N, Warmińsko-Mazurskie; O, Opolskie; P, Wielkopolskie; R, Podkarpackie; S, Śląskie; T, Świętokrzyskie; W, Mazowieckie; Z, Zachodniopomorskie.

Source: Szymańska and Chodkowska-Miszczuk [6] and developed by the authors based on the data collected from the Agency for Restructuring and Modernization of Agriculture (ARMA) and the Local Data Bank of the Central Statistical Office (LDB CSO).

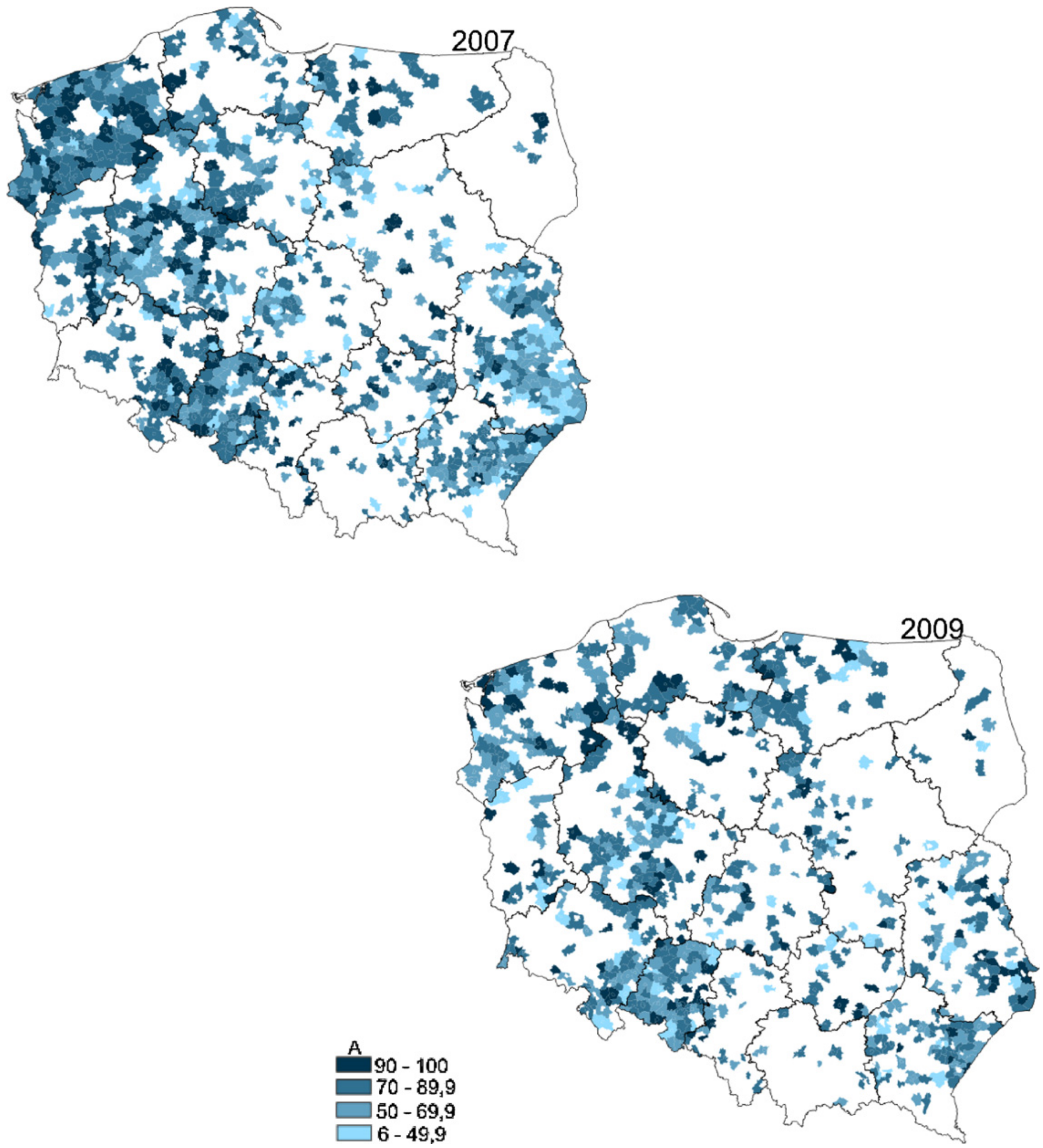


Fig. 2. Percentage of members of gmina councils with secondary or higher education in the gminas where energy crops were cultivated in the years 2007–2009. Explanation: (A) percentage of gmina council members with secondary or higher education.

Source: Developed by the authors based on the data collected from ARMA and LDB CSO.

population at the working age is much higher in the gminas of western and north-western Poland (Fig. 1). The areas of a higher share of population at the working age also have a larger area taken by energy crops. As a result, it may be assumed that there is a certain interdependency between the percentage of population at the working age and the area taken by energy crops. This interrelation is supporresult, it may be assumed that there is a certain interdependency between the percentage of population at the working age and the area taken by energy crops. This interrelation is supported by the value of the correlation coefficient, which in 2007 amounted to $r = 0.235$.

In the study period the number of gminas with a significant share of population at the working age increased. The largest changes were recorded in 2009 (in comparison to the previous year). Taking into account a generally larger proportion of population at the working age in the western and north-western parts of Poland it can be concluded that energy crops production concentrated in these areas, while the area of such crops in both eastern and south-eastern parts of Poland diminished (the areas where traditionally there is a lower percentage of population at the working age).

3.2. Biomass production in relation to the education level of local self-government members

Undertakings connected with functional diversification of a local economy, including the production of biomass, needs developing contacts and cooperation of both central and self-governmental authorities [8]. In Poland, since the beginning of the 1990s and in accordance with the legal act on territorial self-government [9], the local self-government takes responsibility for increasing economic, social and infrastructural attractiveness of a given gmina. In the case of Polish farmers the most important body for socio-economic contacts is a local self-government. As the research indicate 90% of all interactions between farmers and diverse public institutions is with local authorities [10].

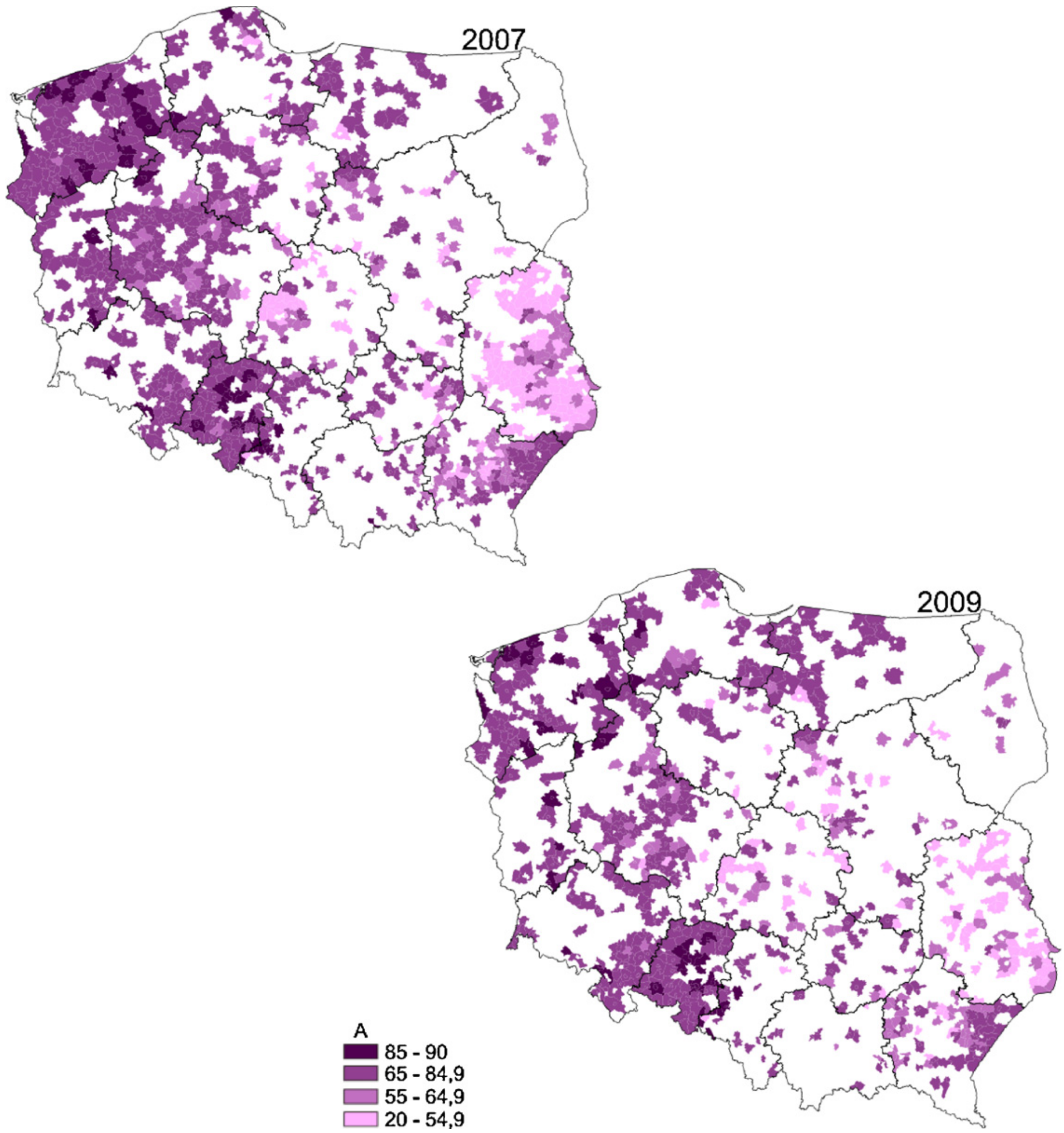


Fig. 3. Percentage of votes supporting Poland's accession to the European Union in the gminas where energy crops were grown in the years 2007–2009. Explanation: (A) percentage of the "yes" votes in the national referendum on Poland's accession to the European Union and the ratification of the Athens Treaty (7–8 June 2003).
Source: Developed by the authors based on the data collected from ARMA and National Electoral Commission.

As mentioned above, this paper aims to estimate whether the education level of members of gmina council is one of determinants favouring, both verbally and organizationally, the biomass production in individual gminas. Biomass production is such an innovative development, and is not only connected with the education level of the producers [11], but also of the self-government authorities (e.g. gmina council). Considering in those terms the gminas where energy crops were grown, serious discrepancies were recorded between western and south-eastern Poland.

The study included the education level of all members of gmina councils who obtained either a secondary or higher degree. The best situation in those terms was recorded in western and south-western parts of Poland: Zachodniopomorskie, Wielkopolskie, Dolnośląskie and Opolskie voivodeships. It is worth mentioning that in 2007 these voivodeships had 60% of the total number of the gminas where the gmina council members with secondary of higher education made up 90% or more of the total number (Fig. 2). This corresponds well with the spatial distribution of gminas according to the area of energy crops cultivation [6].

The importance of the education level of the local authorities in terms of initiating undertakings leading to energy crops cultivation is supported by the fact that there is a correlation between the share of the gmina council members with secondary or higher education and the area of energy crops of 200 ha or more. The highest value of the correlation indicator of $r = 0.234$ was recorded in 2007, that is in the first year of the subsidies for such production co-financed from the EU. This correlation was not that clear for the gminas where the energy crops took a smaller area.

3.3. Support for Poland's accession to the European Union and cultivation of energy crops

Another factor which influences the development of alternative energy in rural areas is the social activity of their citizens. It is, for instance, manifested by their stance towards the accession of Poland to the European Union. As many researchers stress, the acceptance or the lack of it remains a complex issue, conditioned by socio-cultural, historical, political and economic factors [12,13].

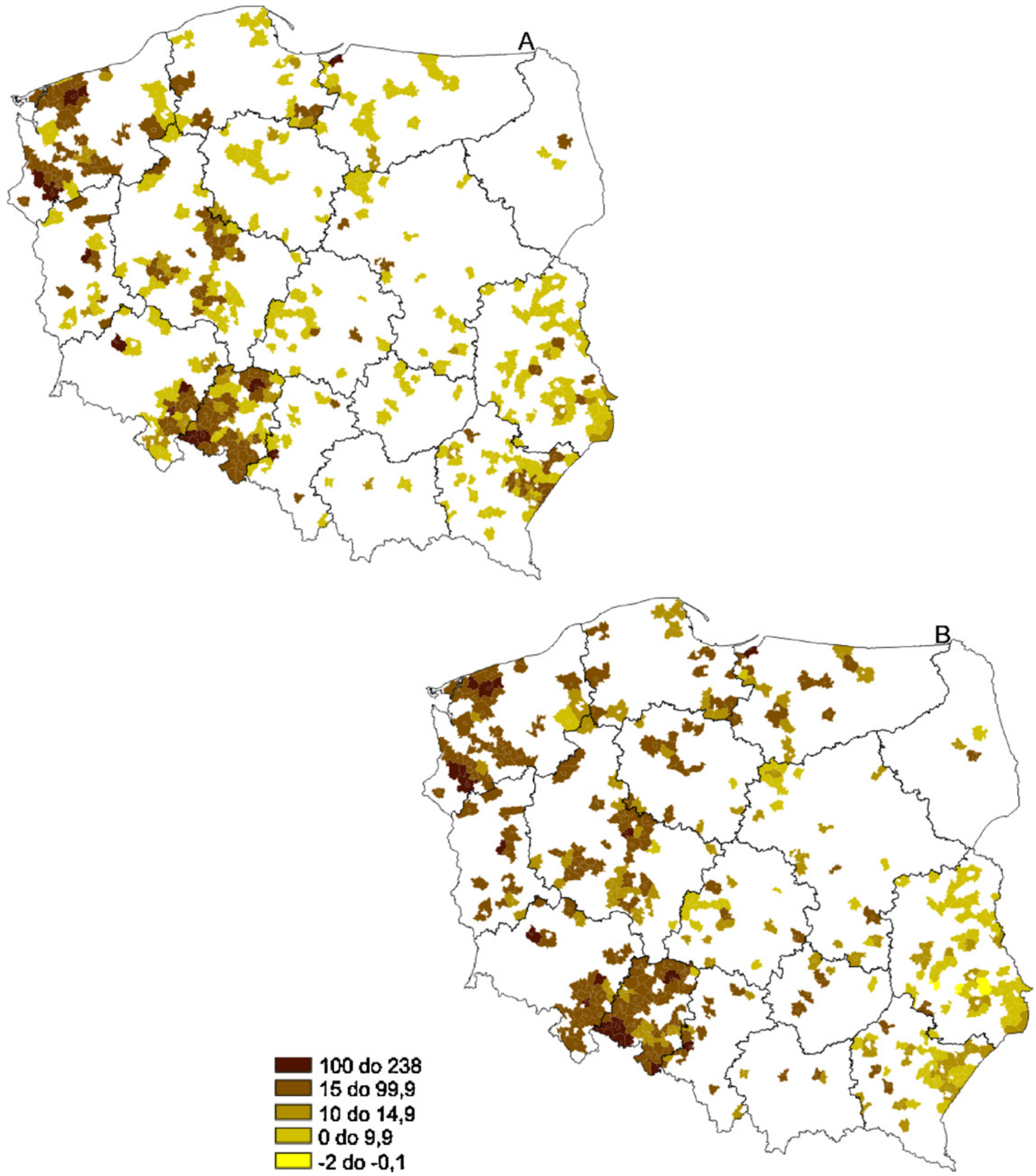


Fig. 4. Results of the segmented regression for the area taken by the energy crops per 1000 ha of farmland. Explanation: (A) mean area taken by energy crops; and (B) estimated mean area taken by energy crops.
Source: Developed by the authors based on the data collected from ARMA.

A significant difference between western and south-western, and central and eastern Poland was recorded in terms of the support for Poland's accession to the EU in the gminas which produce energy crops (Fig. 3).

A higher level of support for the accession process correlates with the larger area taken for energy crops, which were subsidized from the EU budget in the years 2007–2009. The gminas which produced energy crops in those years recorded a positive value of the correlation coefficient between the area taken by energy crops and the percentage of "yes" votes in the national referendum on the accession to the EU. It amounted to $r = 0.244$ in 2007, to $r = 0.235$ in 2008, and $r = 0.224$ in 2009. The highest share of the "yes" votes, up to 90%, was recorded in the gminas of the Opolskie, Dolnośląskie and Zachodniopomorskie voivodeships, while the lowest, below 30%, is characteristic for the Lubelskie, Mazowieckie and Łódzkie voivodeships. As the earlier studies reveal [6] these were mostly the gminas where the area taken by energy crops was the largest.

4. Energy crop production against socio-demographic factors on the basis of the analysis of the segmented regression

From among all the gminas which produced biomass based on energy crops, 408 conducted such activity every year. As the relation between the area of the energy crops cultivation and the socio-demographic factors was not always a linear one, a segmented regression was used in the analysis.

The estimated value (y) was composed of the arithmetic mean of the area taken by the energy crops per 1000 ha of farmland in 408 gminas in the three study years (2007–2009). The independent variables included the three aforementioned socio-demographic

factors. Similarly to the energy crops area, only an arithmetic mean for the 408 gminas from the years 2007 to 2009 was taken into consideration.

The analysis of the segmented regression gave the following equation:

$$Y = (-70.7 + 107.5x_1 + 25.7x_2 - 2.32x_3) \times (Y \leq 84.3) + (-580.8 + 1017.6x_1 - 37.6x_2 + 100.15x_3) \times (Y > 84.3)$$

Y is the area taken by the energy crops per 1000 of farmland; x_1 the percentage of population at the working age; x_2 the percentage of positive answers in the pre-accession referendum in 2003; and x_3 is the percentage of gmina council members with secondary and higher education.

The value of the coefficient of determination ($R^2 = 0.823$) means the above equation of regression is correct. The obtained results indicate that the area taken for energy crops cultivation is positively correlated with the percentage of population at the working age (x_1). The next independent variable, i.e. the percentage of the positive answers ("yes") in the pre-accession referendum (x_2) exerts influence only in the case of small area taken by energy crops, i.e. up to the breakpoint of $Y \leq 84.3$ ha/1000 ha of farmland. Above that point the role of this variable is the opposite. A similar situation, i.e. a diverse influence over a dependant variable (the area taken by energy crops) in both equations of regression, was recorded for the share of the members of gmina councils with secondary and higher education (x_3). The influence up to the breakpoint is negative, while above it is positive. Such a result was also recorded for the year 2007, when a significant dependency between the secondary and higher education level of the members of the local authorities and the area taken by the energy crops of 200 ha or over was visible. A specific breakpoint (during earlier study) was selected at the level of 200 ha.

In accordance with the analysis of the regression, the main factor conditioning innovative undertakings, which include cultivation of energy crops, is the share of young people open to new challenges. An important role is also played by the social activity of the citizens of a given gmina as well as its local authorities. According to the results, those gminas where the area taken by the energy crops was relatively low (84.3 ha per 1000 ha farmland) introduction of such crops was not only conditioned by a relatively high proportion of population at the working age, but also the level of acceptance for the EU expressed at the pre-accession referendum. However, for the gminas where the area taken by the energy crops exceeded 84.3 ha per 1000 ha of farmland, a correlation was recorded not only with the population at the working age, but also with the education level of the gmina council members.

A very interesting pattern of spatial distribution is revealed for both real (A) and estimated (B) values of energy crops per 1000 ha of farmland (Fig. 4). According to the model, the assumed area taken by the energy crops will diminish in eastern and south-eastern Poland, while in the western and south-western Poland it will grow.

As it can be concluded from Fig. 4, energy crops field of gminas which specialise in the cultivation of the energy crops in western and south-western Poland not only correlate with the higher percentage of population at the working age, but also with the higher support for the Poland's membership in the European Union.

5. Conclusions

As the results of the research indicate, the most important endogenous social factor which conditions the development of biomass production based on crops is the percentage of population at the working age, that is relatively young people. Much larger area taken by the energy crops in western Poland correlates with the higher percentage of population at the working age in that part of the country.

Young people, as well as those presenting a positive stance in terms of Poland's membership in the European Union, more often take the risk connected with the introduction of innovative solutions, such as cultivation of energy crops. There is an important role to be played by local authorities in those terms as well. Qualification, which condition creativity connected with such issues as the absorption of the EU funds, are based on both experience and education level. Positive influence of the local authorities over the dissemination of cultivation of energy crops is recorded in the gminas where the area taken by energy crops is relatively large.

Besides socio-demographic factors, diversification of economic activity in rural areas towards biomass production based on energy crops is conditioned by organizational, technical and environmental factors, which need further analysis. Undoubtedly, in order to guarantee positive outcomes of such undertakings high quality of human factor is required. Thus, the activities leading to larger competitiveness of rural areas need investments into the human factor, including the development of a civil society open to innovative undertakings.

References

[1] Machan MK. Sustainable cultivation concepts for domestic energy production from biomass. Crit Rev Plant Sci 2001;20:1–14 [in English].
[2] Sims HR, Hastings A, Schlamadinger B, Taylor G, Smith P. Energy crops: current status and future prospects. Glob Change Biol 2006;12:2054–76 [in English].
[3] Grzybek A. Directions of biomass development for energy purposes. Tomorrow's Countryside 2003;9(62):10–1 [in Polish].
[4] Kościk B, Głowacka A, Kowalczyk-Juśko A, Wyłupek T. Estimating the biomass potential for energy purposes to the direct combustion – methodological problems, The Polish Association of Agricultural and Agribusiness Economists. Sci SERiA Ann 2005;7(7):160–5 [in Polish].
[5] Jasiulewicz M. Local development based on biomass from agriculture, The Polish Association of Agricultural and Agribusiness Economists. Sci SERiA Ann 2007;9(1):193–7 [in Polish].
[6] Szymańska D, Chodkowska-Miszczuk J. Endogenous resources utilization of rural areas in shaping sustainable development in Poland. Renew Sustain Energy Rev 2011;15:1497–501 [in English].
[7] www.creativeclass.org [17.09.2010, in English].
[8] Paine LK, Peterson TL, Undersander DJ, Rineer KC, Bartelt GA, Temple SA, et al. Some ecological and socio-economic considerations for biomass energy crop production. Biomass Bioenergy 1996;10(4):231–42 [in English].
[9] Act of Local Government of 8th March 1990 (Official Journal of Republic of Poland 1990, No. 16, pos. 95) [in Polish].
[10] Act of Local Government of 8th March 1990 (Official Journal of The Republic of Poland 1990, No. 16, pos. 95) [in Polish].
[11] Chodkowska-Miszczuk J. Renewable energy sources – the social dimension. Manuscript in the Department of Urban Recreation Studies, Institute of Geography, Nicolaus Copernicus University in Toruń; 2011. p. 30 [in Polish].
[12] Kowalski M. Electoral behavior of the rural population and the socioeconomic situation in rural areas – the identification process. In: Bański J, editor. Contemporary transformation and the future of rural areas ias in Poland, vol. 4. Rural Areas Study Group (RASG) Institute of Geography and Spatial Organization (IGSO) PAS, Committees of Rural Areas Polish Geographical Society (CRA PGS), Rural Studies; 2006. p. 131–44 [in Polish].
[13] Gorzelak G. Socio-economic regional differences in Poland. In: Zagórski K, Gorzelak G, Jałowiecki B, editors. The diversity of life. Polish families and communities. Warsaw: Scientific Publishing Scholar; 2009. p. 86–147 [in Polish].